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discussing these problems, I wish, however, to expose the merits of this novelty as bearing on the following five several interests:—

1° On the interest of Society in general;
2° On that of the borrower;
3° On that of the lender;
4° On that of the bankers;
5° On that of speculators.

§ 5. The public interest is my first motive in bringing forward this scheme. It is intended to compete with, not to supersede, other forms of bonds. Nothing of the kind has to my knowledge ever been projected. It certainly has one feature in common with some existing lottery loans, viz., the accumulation of interest. But in all those lottery loans the real rate of interest is wrapped in obscurity. The meagreness of that rate is always concealed under a "*toilette tapageuse*" of a few monster prizes which serve as baits to the unwary. They all, moreover, postpone the repayment of capital to the remotest possible date, whereas my bonds are paid off in equal numbers from the first to the last year of the loan. *I disclaim all solidarity with lottery loans as hitherto organized,* and believe these to be deceptive and immoral, as appealing to the passion of gambling.

§ 6. *The savings of our forefathers constitute the riches of the Nation.* To promote and encourage individual savings is to promote the welfare of the State, as well as that of each family and individual concerned. Therefore every scheme which is calculated to stimulate thrift well deserves the support of the Government and of the public. The annual drawing need not prove a stumbling-block to enemies of gambling. It cannot be said to appeal to the passion of gambling, but forms only an innocent and wholesome attraction. The sporting element in these bonds, so far from being a danger, will offer a wholesome counter-attraction to the unhealthy temptations of the Stock Exchange and of lottery bonds.

§ 7. The State as a borrower has evidently an interest in increasing the demand for the public funds. If, as I believe, *this scheme would bring in a new class of investors*, the State ought surely, in the interest of the taxpayers, to give it a fair trial. The system of issuing perpetual annuities seems to me onerous, improvident, and unjust. Have we a right to saddle all future generations with a perpetual charge for the sake of defraying our present necessities? There can be but one answer to this question. A debt contracted, say a hundred years ago, at five per cent. has already been repaid five times in the shape of interest, yet it remains immoveably fixed on our shoulders till the end of time or rather till the national bankruptcy. This is the inevitable result of the present financial policy of all Europe. Our own fitful and precarious Sinking Funds, which are sacrificed at the first pressure, cannot in the long run save us.

§ 8. *Terminable annuities* have now asserted themselves most successfully in theory and practice. They are open, however, to one great objection, stated as follows by McCulloch: "We look upon all attempts and particu-
" larly those made by Government to get individuals to
" exchange capital for annuities as radically objectionable,
" and as being subversive of principles which ought to
" be strengthened rather than weakened." The accumulative bond is not open to the above just criticism. Far from dissipating it doubles the capital of individuals, while affording to the State all the advantages of a terminable annuity. It thus forms a happy and necessary development

of the institution of terminable annuities. This novelty will bring in a new class of investors, and will, by lowering the rate of interest, and *limiting the duration of loans*, reduce the burdens of the taxpayers. I think, therefore, that I have proved my case as regards the interest of the nation as a borrower and as a taxpayer.

§ 9. The same advantages would accrue to any *joint-stock company borrowing money.* Perpetual debentures are really the most costly mode in which to borrow money, and ought never to be employed. A 5 per cent. loan of one million issued on this principle would in a century cost five millions for interest alone, leaving the principal unaltered. The average type of French and Belgian railway debentures consists in an obligation of Fr. 500 nominal, paying 3 per cent. interest, issued at about Fr. 300, and redeemable at Fr. 500 by drawings spread over ninety years. These drawings are, however, quite infinitesimal during the first years of the loan. The mean term of redemption is not, as might be supposed, forty-five, but about seventy years. This fascinating bonus of Fr. 200, payable in seventy years, is at present worth only Fr. 6·57, a fact not apparent to the average investor. The aggregate charge entailed on the borrower by a loan of Fr. 1,000,000 on this principle would be ninety annual payments of 53,766 = Fr. 4,838,940. On the accumulative principle, a 5 per cent. loan of one million would be extinguished by 31 annual payments of Fr. 63,849 (omitting fractions), an aggregate of 2,000,000, thus involving a saving of Fr. 2,838,940. These figures are conclusive as to the advantage of the accumulative principle to the interests of borrowers.

§ 10. Thirdly, *the investing public* will profit equally with the State by this innovation. That numerous class of investors who wish to double their capital without any trouble or risk will find here the only security suitable to their purpose. They will no longer have to call on a broker twice or four times in a year in order to invest some minute dividend. Their capital is growing every day at compound interest, and comes back to them doubled without trouble, loss, risk, or correspondence. The probabilities of repayment, and consequently the value of the bond, increase from year to year in a simple mathematical ratio which can be calculated by a child. These are solid advantages which must attract all those who require *a good "Lock-up,"* or what the French call a *"Placement de père de famille."*

The following are some eloquent figures showing the immense difference of value which results from a difference in the term of repayment.

Present value at five per cent. of £100 payable at the end of the following terms:—

YEARS......	15.	25.	30.	50.	70.	90.
£	48.10	29.53	23.13	8.72	3.28	1.22

§ 11. The *interest of the banker or financial firm* which issues a similar loan must be identical with that of the borrower. I am convinced that a new loan on this principle would be eagerly sought after, if the principle were sufficiently explained to the public. This is a fair conclusion from the favour shown to the old type of railway obligations, which offer a large bonus on redemption. If then these homœopathic drawings exercise such an attraction, it is reasonable to suppose that the real tangible bonus offered by accumulative bonds would be proportionately appreciated by the investing public. If this surmise is correct, a loan on this principle would be readily floated, and the bankers' profit would be assured. If even the public did not at first respond, they could hardly lose anything beyond the cost of the paper. So many different forms of bonds have been tried that surely some one will be found to offer this new and original bond to the public.

§ 12. The fifth and last advantage of the accumulative bond consists in its *convenience for speculators.* The absence of coupons must enormously simplify all operations connected with buying, selling, quoting, pledging, and "carrying over." The quoted price of coupon bonds is influenced by the amount of the accruing interest. The price of the accumulative bond is not vitiated by any such extraneous element, but would rise gradually from year to year, subject of course to political and financial fluctuations. Transactions would not be hampered by coupons and contangoes. This feature will be readily appreciated by the Stock Exchange.

§ 13. The amount and annual charge of the National Debt of Great Britain is officially stated to have been as follows on the 31st of March, 1886:—

	CAPITAL.	CHARGE.
	£	£
Funded Debt	638,849,694	18,793,179
Unfunded do.	17,602,800	476,046
Annuities	85,829,917	3,502,134
Total	£742,282,411	£22,771,359

§ 14. If *England is ever to pay off her National Debt, it must be by means of terminable annuities.* The accumulative bonds, which form an improvement and development of the same principle, will assist materially in realising the above consummation. As Consols are now quoted about par, the interest of 3 per cent. may be assumed as the exponent of the national credit. At this rate of interest an annuity of £38,042 would redeem a capital of £1,000,000 in 52.57 years. Therefore an annuity of £24,303,122 would redeem the whole funded debt of £638,849,694 within the same period. This would only add £5,509,943 to the present permanent charge of the funded debt, which is £18,793,179 per annum. An accumulative bond of £200, costing to the Treasury £3.80 per annum, might be offered to each fundholder in lieu of his present stock producing £3 per annum. This option, if generally adopted, would indeed bring us gradually within a measurable distance of the *extinction of the National Debt.*

§ 15. 22¾ millions of our revenue are now mortgaged to the national creditor! No present sacrifice would seem to be too great for the sake of releasing this colossal income! This indeed would be a splendid legacy to leave to posterity! As compared with the magnitude of this object, the temporary sacrifice would seem to be trifling. *5½ millions more would have to be found for* 31 *years.* The British population of 19,076,868 in 1813 raised a revenue of £108,397,645. Surely now in a season of peace, with a population and wealth increased two or threefold, we could easily provide £95,000,000 if that were necessary. There are two most legitimate taxes which, if required, would produce without any serious friction the above necessary revenue. These are—

> 1° A *moderate customs duty on imports.* Foreign produce and manufactures are now imported into the United Kingdom for home consumption to an average annual value of £304,594,448, without

paying any duty. Surely this colossal amount of wealth, which receives the protection of our laws, might contribute something towards our burdens now exclusively thrown on British industry alone. The sugar duties which once [in 1875] produced £6,383,000, would alone supply much more than the sum required.

2° An *export duty on coal* would fulfil a double purpose in feeding the revenue and checking the waste of our capital.

§ 16. *The National Debt is a "Tub of the Danaïdes."* Hundreds of Millions have vainly been poured into this bottomless abyss. Lord Iddesleigh's Sinking Fund has lived no longer than that of Mr. Pitt. Some uncertain amount is still devoted to the redemption of debt on a desultory system. The same amount applied on a definite and mathematical principle would have a much more tangible effect. Our present debt has been the growth of one hundred and thirty years, having risen to its maximum of £839,382,145 in 1817. At our present rate of progress it will require two or three centuries to effect its final redemption. I am convinced that accumulative bonds will enable us more regularly and rapidly to attempt the above colossal operation.

§ 17. *Accumulative bonds are equally suitable for all public loans,* whether issued by states, corporations, or companies. The great advantage of a terminable annuity is that it compels the repayment of debt.

No loan should be contracted without a provision being made for its repayment. This is a duty which should not be transmitted to posterity as is usually the case. The borrower who wishes to effect this object by annually investing his savings will find many difficulties in his way.

Consols themselves are exposed to fluctuations, and hampered by commissions and stamps on transfer. A terminable annuity is clearly the true method by which to pay off a debt regularly and conveniently out of annual income. But I maintain further that in the interest of the lenders the annuity should be divided into accumulative bonds.

§ 18. TABLE OF AMORTIZATION of a loan of £1,000,000, divided into 10,000 bonds of £100 each, to be paid off at £200 by equal annual drawings, showing the amount of each Annuity, the number of Annual payments, and the number of Bonds to be paid off in each year, at various rates of interest:—

Rate of Interest per cent.	Annuity. £.	Years.	Bonds paid off annually.
3	38,042.08	52.5733	190.2104
3¼	41,248.17	48.4869	206.2409
3½	44,459.89	44.9843	222.2994
4	50,900.27	39.2925	254.5014
4½	57,868.35	34.5654	286.3167
5	63,849.29	31.3237	319.2464
5½	70,358.25	28.4259	351.7913
6	76,890.41	26.0110	384.4521
7	90,024.91	22.2160	450.1246
8	103,254.11	19.3696	516.2706
9	116,579.30	17.1557	582.8965
10	130,001.84	15.3844	650.0092
11	143,523.12	13.9350	717·6156
12	157,144.52	12.7271	785.7226

§ 19. In the above table I assume that a State or Corporation issues a loan of £1,000,000, redeemable by a number of equal annual payments amounting in the aggregate to £2,000,000, whatever the rate of interest may be. This is the one immutable basis of the "accumulative" loan.

The principle adapts itself to every rate of interest. There are *three variable terms* to every such loan, viz.:—

1° The rate of Interest;
2° The amount of the Annuity;
3° The duration of that Annuity, *i.e.* the number of Years.

These three quantities are strictly interdependent, *i.e.*, they bear a certain mathematical ratio to each other. When once that ratio is ascertained, any one of the three terms being given will suffice to elicit the other two. This discovery opens out a most interesting mathematical study. In such loans there are consequently three problems to be solved. Their accurate solution requires the use of logarithms; but for practical purposes they may be solved with sufficient accuracy by simple arithmetic with the assistance of a table of annuities.

At the rate of interest of 2 per cent. per annum—

The amount of the Annuity would be	£25,274.97
The number of Years would be ...	79.1336
The number of Bonds paid off annually would be	126.3748

It should be mentioned that the original amount of the loan is identical with the "present value" of the annuity.

§ 20. Problem I.—*The rate of Interest being given, it is required to know the amount of each Annuity, and the number of Years.*

Take a table of "Present Values," and look down the column of the given rate till a present value is found, which is equal to half the number of years standing opposite to it. That number will represent the true number of Years. As, however, probably no such present value will be found in the table, we can find that present value with sufficient accuracy by interpolation. First take the two adjoining present values which come nearest to the true present value, *i.e.* to half the number of Years standing opposite. Thus, if the rate of interest be 5 per cent., on looking down the table of "Present Values" we find the present value of £1 per annum—

For 31 years to be £15.5928 [more than half the years].
,, 32 ,, £15.8027 [less than half the years].

We know that the present value (*i.e.* the original loan) is equal to one-half of the sum of the annual payments. Therefore as 31 years are too few, and 32 years are too many, the true number must be somewhere between 31 and 32 years. We also know that the number of years must be exactly double the present value; therefore that, if half the number of years were substracted from the present value, the remainder would be zero. But here, as the present value—

For 31 years is not £15.5000, but £15.5928,
therefore too much by + ... .0928
And for 32 years is not £16, but £15.8027,
therefore too little by — ... ... .1973

The sum of these two discrepancies, viz. ... 0.2901

represents the effect of one year on the present value. In other words, a difference of one year in the time makes a difference of £0.2901 in the present value. As therefore 31 years are too little in the above proportion, it may be assumed that the fraction of a year to be added to 31 years will bear the same ratio to one year as .0928 does to .2901. This ratio is easily found by the following "Rule of Three"—

$$.2901 : .0928 :: 1 : x. \qquad x = .3195$$

Therefore the number of years would be 31.3195. This figure, however, is less accurate than that of 31.3237, inscribed in the table as resulting from direct calculation. When once the number of annual payments is found, the amount of each payment is found by merely dividing the sum of these payments, which we know to be £2,000,000, by the number of years, viz., 31.3195. The quotient £63,857.97 again varies slightly from the true Annuity, which is £63,849.29.

§ 21. Problem II.—*When the amount of the Annuity is given, it is required to find the rate of Interest and the number of Years.*

Assuming the amount of the Annuity to be £50,000, the number of years may be found by dividing £2,000,000, the sum of the payments, by 50,000, which gives 40 years. Then take a table of Annuities and look through the present values of an Annuity of £1 for 40 years until we find two consecutive rates of Interest as close as possible, under one of which there is a present value greater than 20, and under the other a present value less than 20. We know that the present value of the Annuity is always half the number of years, therefore in this case 20. The required rate of Interest will therefore be between the above two consecutive rates, and may be found with sufficient accuracy by interpolation.

At 3¼ p. c. the Present Value is too much, viz.	20.55099
At 4 p. c. ,, too little, viz.	19.79277
The difference therefore	.75822

represents the difference in present value corresponding to a difference of one quarter or 0.2500 in the rate of Interest.

The following, then, is the formula applicable to this problem:—

20.55099—19.79277 : 20.—19.79277 : : 4—3¼ : x.

The Present Value at the required rate we know to be .	20.00000
,, at 4 p. c. we have found to be . .	19.79277
Difference . . .	0.20723

The rate of Interest decreases as the Present value increases, though not in a strictly inverse ratio. We may, however, assume, for facility of calculation, that the differences are proportional. We have found that the true present value at the required rate of Interest is greater than the present value at 4 p. c. by 0.20723. We may assume therefore that the true rate of Interest is less than 4 p. c. by a fraction which shall bear the same ratio to ¼ that .20723 bears to .75822, the figure representing the difference in present value corresponding to a difference of ¼ in the rate of Interest. We therefore say:—

$$.75822 : .20723 :: \tfrac{1}{4} : x.$$

x will be found = ... 0.06832
This subtracted from 4.00000
gives the required rate of Interest, viz. . 3.93168

§ 22. Problem III.—*The number of years being given, it is required to find the amount of the annuity and the rate of interest.*

When the number of annual payments is given the amount of each may be found by simply dividing the sum of these payments by the number of years. In the supposed case of a loan of £1,000,000 to be paid off by twenty equal annual payments, making a total of £2,000,000, it is easy to see that the amount of each payment is £100,000. We know by the fundamental rule that the present value of an annuity of £1 for any number of years at the required rate of interest must be half that number of years, consequently that in the present case the present value must be 10. We proceed again by interpolation, as in the preceding problem; on looking down the table of annuities we find that the present value of an annuity of £1 for 20 years—